In the matter of

State of Oklaholma, ex rel., A. Drew Edmondson in his capacity as Attorney General of the State of Oklahoma, and Oklahoma Secretary of the Environment, C. MILES TOLBERT, in his capacity as the Trustee for Natural Resources for the State of Oklahoma, Plaintiffs

v.

Tyson Foods, Tyson Poultry, Tyson Chicken, Inc., Cobb-Vantress, Inc., Aviagen, Inc., Cal-Maine Farms, Inc., Cargill, Inc., Cargill Turkey Products, LLC, Georges, Inc., George's Farms, Inc., Peterson Farms, Inc., Simmons Foods, Inc., and Willowbrook Foods, Inc.
Defendants.

CASE NO. 05-CV-329-GFK-SAJ

in the United Station District Court
for the Northern District of Oklahoma

Expert Report

of

Roger L. Olsen, Ph.D.
CDM
555 17th Street, Suite 1100
Denver, CO 80202

EXHIBIT
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poultry related contaminants are pervasive through out the IRW, the overall water quality characteristics of the surface waters in the IRW have been substantially changed when compared to surface water quality in reference locations.

- The chemical and bacterial concentrations in each environmental component are consistent with known fate and transport processes and show a gradient in concentrations from high to low across the IRW depending upon closeness to poultry land application fields. These observations document a complete pathway of the poultry waste contamination from the land applied fields to streams, groundwater, springs, sediments, and Tenkiller water and sediments.

- The chemical compositions of the poultry waste and cattle manure are different from each other and individually unique. In addition, the chemical compositions of leachates of the poultry waste and cattle manure generated using synthetic precipitation are different from each other and individually unique. The chemical and bacterial compositions of poultry waste leachates are different and unique compared to WWTP discharges in the IRW. These differences allow identification of the important sources of contamination in the basin.

- Principal component analysis (PCA) identified two major sources of contamination in the IRW: poultry waste disposal and WWTP discharges. Poultry waste is by far the dominant contamination source in the IRW when compared to other sources. Cattle waste contamination was unique from both poultry waste and WWTP effluent and was identified in some samples with documented cattle manure contamination. However, chemical contamination from cattle waste is not dominant in the basin and only represents a minor source. In the PCA, the chemical and bacterial composition of poultry waste creates a distinct chemical signature that contains both phosphorus and bacteria.

- Mass balance calculations performed using the results of the synthetic precipitation leachates show that cattle manure is a relatively small source of the chemical contamination compared to poultry waste.

- Multiple lines of evidence by other experts (Drs. Engel, Fisher, Teaf and Harwood) support the conclusions that poultry waste is a major source of phosphorus and bacteria contamination in the IRW.

The information and evaluations supporting each of these opinions is provided in the following sections. Other opinions are also included in each section.

Cotter Dolomite of Ordovician age are exposed at the surface. The Burgen Sandstone and Cotter Dolomite are part of the underlying Roubidoux aquifer.

In Oklahoma, the Boone was among the four bedrock aquifers considered highly vulnerable to surface contamination because it contains karst features such as caves, sinkholes, and disappearing streams, which provide direct conduits for precipitation and runoff to transport contaminants to the water table.

Recharge to the Boone hydrogeologic basin is almost entirely from direct infiltration of precipitation. The factors that make the outcrop of the Boone Formation favorable to groundwater recharge also make it vulnerable to contamination. Because soil and subsoil in the Ozarks is thin, near-surface faults and fracture systems are common, and dissolution of the carbonate rocks is widespread, precipitation can quickly infiltrate the unsaturated zone.

Given the geology and hydrogeology, constituents of land disposed poultry waste run off fields into surface water and infiltrate through geologic media and contaminate groundwater. The poultry waste constituents are poorly attenuated during runoff and infiltration. Poultry waste is disposed on fields within the IRW by simple broadcast spreading. The poultry waste is not mechanically incorporated into soils. As a consequence, both soluble and particulate fractions of this material are readily available for transportation through the agency of rainfall. When rain interacts with poultry waste, some of the material goes into solution. This dissolved material can then travel with the water as it moves downward through the soil and vadose zone to pollute the groundwater. Additionally, if sufficient rainfall occurs in a short enough period of time, runoff is produced (i.e. not all of the water can be taken up by the soil and it runs off the field). The dissolved material derived from the poultry waste will also move with the runoff and pollute surface water. Further, this runoff water can also carry particles of poultry waste that will pollute surface water, stream sediments and lake sediments. Because pores can be large in karst, particles can also be transported through the groundwater in karst aquifers. Both runoff and groundwater eventually end up in surface streams that flow to Lake Tenkiller. Thus pollution of the surface of the ground by the disposal of poultry waste as practiced within the IRW results in the pollution of surface water, ground water, stream sediments and lake sediments.

6.4 Sources of Contamination

6.4.1 Chemical and Bacterial Characteristics of Wastes

Table 6.4-1 provides the chemical and bacterial composition of poultry waste and cattle manure (solid samples). **Tables 6.4-2a** and **6-4.2b** provide the chemical and bacterial composition of waters containing various waste sources including edge of field samples, synthetic leachates of poultry waste, synthetic leachates of cattle manure, cattle-influenced springs, effluent samples from WWTPs, and surface waters influenced by WWTP effluent in the IRW. **Table 6.4-3** provides a comparison of the chemical and bacterial compositions of the poultry waste and cattle manure. **Table 6.4-4** provides a comparison of the chemical and bacterial compositions of the data. **Figure 6.5-15** provides graphical representation of the enterococci data. **Figure 6.5-16** provides graphical representation of the TOC data. **Figures 6.5-17** and **6.5-18** provide graphical representation of the total potassium data. The samples for the different components have been separated in order to increase the clarity of the data.

Figure 6.5-19 through **Figure 6.5-26**, provide graphical representation of the data for the different contaminants of interest for the solids components. **Figures 6.5-19** and **6.5-20** provide graphical representation of the total phosphorus (6020) data. **Figures 6.5-21** and **6.5-22** provide geographical representation of the total potassium data. **Figures 6.5-23** and **6.5-24** provide graphical representation of the total copper data. **Figures 6.5-25** and **6.5-26** provide graphical representation of the total arsenic data. The samples for the different components have been separated in order to increase the clarity of the data. These figures are discussed in the next section.

6.6 Indicator Chemicals in Water

The following paragraphs discuss several poultry related contaminants that are widely distributed and pervasive across the IRW. These contaminants include phosphorus, enterococci, total organic carbon, and potassium.

6.6.1 Distribution of Phosphorus through out the Basin – Water

Surface Water: **Figures 6.6-1** through **Figure 6.6-4** are spatial representations of the average concentration of total phosphorus (4500PF) for the various sampling locations. The majority of the locations had concentrations of total phosphorus (4500PF) that were greater than the Oklahoma water quality standard of 0.037 mg/L. **Figure 6.6-3** indicates that the highflow surface water locations in Arkansas tended to have higher concentrations than those sampled in Oklahoma. As shown, phosphorus is widespread and pervasive throughout the entire basin with the average concentrations at most locations above 0.037 mg/L and above background concentrations. Particularly see **Figure 6.6-4a** which provides the results of soluble reactive phosphorus at 194 locations collected in August 2006 over a two week period.

Figure 6.5-2 and **Figure 6.5-3** (introduced in previous section), indicate that the concentration of total phosphorus is highest in the poultry edge of field samples (EOF) and then decreases as the water moves through the various components. The majority of the concentrations of total phosphorus range from 0.6 mg/L to 3 mg/L for the EOF samples. The majority of the concentrations of total phosphorus for the other components are typically lower than 0.1 mg/L. As shown in **Figure 6.5-4** and **Figure 6.5-5**, a very similar trend is seen with the soluble reactive phosphorus (SRP) with the majority of the concentrations for the EOFs ranging from 0.2 mg/L to 1.2 mg/L. The majority of the concentrations of SRP for the other components are typically lower than 0.1 mg/L.

Groundwater: **Figure 6.6-13** is a spatial representation of the average concentration of total phosphorus (4500PF) for the various geoprobe, springs, and well stations. Phosphorus was found in each of these components, with higher concentrations found at the geoprobe and springs stations.

Table 6.4-3: Comparison: Poultry Waste and Cattle Manure

Parameter	Units	Poultry Waste CDM Average	Fresh Cattle Manure Factor	Dry Cattle Manure Factor
Total Potassium	mg/kg	30700	3.31	15.7
Total Vanadium	mg/kg	17.6	2.48	4.28
Total Thallium	mg/kg	0.307	0.216	0.373
Total Sodium	mg/kg	8090	6.69	50.9
Total Silver	mg/kg	8.23	5.8	10
Total Zinc	mg/kg	506	6.83	6.94
Soluble Salts (1:2)	mmhos/cm	11.8	3.06	5.41
pH (1:1)	s.u.	7.93	1.07	1.05
Brevibacteria 16S rRNA	Copies/g	1100000000	n.v.	n.v.

n.v: non value: samples were not analyzed for the parameter of interest for the sample of interest.
Non-detects treated as 1/2 the detection limit